2024 UT Austin Invitational Science Olympiad
Crime Busters B Answer Key

October 26th, 2024

Team Name: _____**ANSWER KEY**_____

Team Number: _____

Important Notice:

- **YOU SHOULD NOT HAVE THIS! IF YOU DO, DO NOT OPEN AND NOTIFY THE EVENT SUPERVISORS IMMEDIATELY!**
- **Failure to disclose the event supervisors on obtaining this will result in an immediate disqualification.**

Directions:

- You will have 50 minutes to complete this exam.
- All answers must be indicated on your answer sheet.
- Point values indicated for all questions are indicated in test booklets.
- The maximum number of obtainable points on this exam is 206.

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Qualitative Analysis (TB2)

1. (50 points) Using the samples provided, fill out each powder's respective chemical formula, name, and one applicable connection between this powder and the story. Mixtures indicated with an asterisk*

Powder #	Chemical Formula (2) Write NA if not applicable	Powder Name (2)	Application in Story (1)
1*	$NaCl + (C_6H_{10}O_5)_n$	**Table Salt + Cornstarch**	**Bulbasaur's Cake**
2*	$C_{12}H_{22}O_{11}$	**Crystal Sugar (Sucrose) + Flour**	**Bulbasaur's Cake**
3	$C_2H_3NaO_2$	**Anhydrous Sodium Acetate**	**Charmander's Electrolyte Drink**
4	$C_{102}H_{151}O_{39}N_{31}$	**Powdered Gelatin**	**Bulbasaur's Cake**
5	$NaHCO_3$	**Baking Soda**	**Bulbasaur's Cake**
6	$NaCl$	**Table Salt**	**Bulbasaur's Cake**
7	SiO_2	**White Sand**	**Charmander's Practice**
8	$CaCO_3$	**Calcium Carbonate (Powdered Limestone)**	**Squirtle's Fountain**
9	$C_6H_8O_7 + NaHCO_3 + C_9H_8O_4$	**Powdered Alka-Seltzer**	**Charmander's Electrolyte Drink**
10	$C_{27}H_{48}O_{20}$	**Cornstarch**	**Bulbasaur's Cake**

2. (10 points) Using the samples provided, fill out each metal's name, use in daily life, and one applicable connection between this metal and the story.

Metal #	Metal Name (2)	Use in Daily Life (1)	Application in Story (2)
1	**Zinc**	**Food, Paints, Rubber, Cosmetics, Pharmaceuticals, Plastics, Inks, Soaps, Batteries, Electrical Equipment**	**Squirtle's Batteries**
2	**Tin**	**Food Containers, Bronze, Electronics, Solder**	**Bulbasaur's Canned Strawberries**

3. (15 points) Using the samples provided, fill out each liquid's name, use in daily life, and one applicable connection between this liquid and the story.

Liquid #	Chemical Formula (1)	Liquid Name (2)	Application in Story (2)
1	C_3H_8O	**Rubbing Alcohol (Isopropyl)**	**Ditto's Cleanup**
2	H_2O	**Water**	**Bulbasaur Gardening Squirtle Gardening Ditto's Cleanup**
3	CH_3COOH	**Vinegar**	**Ditto's Cleanup**

4. (2 points) Write the complete, balanced chemical reaction between sodium bicarbonate and hydrochloric acid. Include states of matter.

Solution: $NaHCO_{3(s)} + HCl_{(aq)} - - > NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$
(1 for correct reactants and products, 1 for correct states of matter)

5. (1 point) Why is HCl considered a strong acid?

Solution: HCl and other strong acids completely dissociate in water.

6. (2 points) Why does heat oftentimes increase the solubility of a compound?

Solution: Heat increases the KE of the molecules which can overcome IMFs within the solution.

7. (1 point) What does anhydrous mean?

Solution: Without water.

8. (1 point) Bleach **oxidizes** melanin in human hair to change its colour.
9. (2 points) Reduction is a(n) **gain** of electrons while oxidation is a(n) **loss** of electrons.
10. (4 points) Identify the oxidation agent, reducing agent, and oxidation numbers in the following reaction: $MnO_4^- + 5Fe^{2+} - - > Mn^{2+} + 5Fe^{3+}$

Solution:
Oxidation Agent: MnO_4^- **(1)**
Reducing Agent: Fe^{2+} **(1)**
MnO_4^-**: +7 (0.5)**
Fe^{2+}**: +2 (0.5)**
Mn^{2+}**: +2 (0.5)**
Fe^{3+}**: +3 (0.5)**

11. (2 points) Hydrogen Peroxide acts as a(n) **oxidizing agent** to breakdown the **hemoglobin** molecules in blood, allowing it to "wash-out" of stained clothing.
12. (2 points) In which phase of hair growth do hairs not grow? Give an estimate to how long this phase lasts.

Solution: Telogen (1); 2 - 5 months (1) (Any length of time between this range OK)

13. (2 points) Nitrogen fixing bacteria convert **Atmospheric Nitrogen (N_2)** into **Ammonia (NH_3)**.
14. (2 points) Explain why iron is magnetic but aluminum is not.

Solution:

- **Iron is ferromagnetic where there are 4 unpaired electrons. The electrons, when aligned parallel to each other, create magnetic domains. (1)**
- **Aluminum is paramagnetic with only 1 unpaired electron. The single unpaired electron is not sufficient to induce magnetic behaviour. (1)**

15. (2 points) Static electricity is the result of an imbalance of positive and negative charges, but unlike current electricity, remains stationary until discharge. Name two factors that may impact its increased prevalence in the winter compared to the summer.

Solution: Low humidity, low temperatures, synthetic clothing material, increased insulation.

16. (2 points) The combination of yeast, flour, and water result in the process of **fermentation**. This process **does not** require oxygen.

Polymer Testing/Natural and Man-made Substances (TB3)

17. (6 points) Using the information found in your image sheet, fill out the table with each plastic's respective information.

Plastic #	Abbreviated Name (1)	IUPAC ID(1)	Formula (1)
1	**HDPE**	**High Density Polyethylene**	$(C_2H_4)_n$
2	**LDPE**	**Low Density Polyethylene**	$(C_2H_4)_n$

18. (2 points) Name two differences between the two plastics.

Solution:

- **LDPE is softer/more flexible than HDPE**
- **LDPE has a lower melting point**
- **LDPE is transparent whilst HDPE is opaque**
- **HDPE has better tear resistance**
- **HDPE has better tensile strength**

19. (8 points) Using Figures 1 and 2, found in your image sheet, fill out the table with each fiber's respective information.

Fiber #	Organic/Synthetic (2)	If organic, animal or vegetable? If synthetic, write "NA" (1)	Application in Story (1)
1	**Organic**	**Vegetable**	**Bulbasaur's Plants**
2	**Organic**	**Animal**	**Any Pokémon**

20. (4 points) Using Figures 3 and 4 in your image sheet, fill out the table with each hair's respective information.

Fiber #	Identify the species of hair (1)	Application in Story (1)
1	**Human**	**Any Mention of Pokétrainers**
2	**Rat**	**Rattata**

Chromatography

21. (10 points) Charmander left you three samples of their electrolyte drink! Use the provided samples to create 3 chromatography sheets. Staple these to the **FRONT** of your final exam. Label with your team number in pencil.

Solution: For EACH Chromatogram:

- **Correct marking at bottom of paper (1)**
- **Clear that paper was not submerged further than the initial pen marking (1)**
- **"Decent" looking chromatogram (1)**

If all 3 look "decent" (1)

Crime Scene Physical Evidence

22. (5½ points) Detective Pikachu identified parts of some fingerprints left at the crime scene. Label each of these fingerprint characteristics using Figure 7 in your image sheet. Some terms may or may not repeat.

    A: **Bifurcation**

    B: **Ridge Ending**

    C: **Short Ridge**

    D: **Ridge Ending**

    E: **Ridge Ending**

    F: **Ridge Ending**

    G: **Ridge Crossing**

    H: **Bifurcation**

    I: **Island**

    J: **Enclosure**

    K: **Bifurcation**

23. (1½ points) Where are the three regions from which a fingerprint begins to develop?

    Solution: The tip of the finger, the crease at the base of the fingertip, and where the finger bends.

24. (2 points) Detective Pikachu dusted surfaces at the scene of the crime. What type of print is this? What allows for this visualization?

    Solution: Latent Print. (1) The fingerprints leave sweat and oil when touching a surface. (1)

25. (2 points) The soil at the crime scene was found to have contained 35% silt, 30% sand, and 35% clay. Identify the soil classification.

    Solution: Clay Loam

26. (1 point) What is the ideal pH of soil for plant growth?

Solution: 6 - 8

27. (2 points) What are the three components of a soil's mineral fraction?

Solution: Silt, sand, and clay particles. (all or nothing)

28. (2 points) Detective Pikachu discovered some blood splatters on the way to the golden berries. Rattata, a rat pokémon, must have bit someone when trying to escape! Describe the direction of movement of blood spatter 1 under Figure 6.

Solution: Left to Right going Forward (Same as West to East)

29. (2 points) Using Figures 5 and 6, describe the difference between blood spatters 1 and 2.

Solution:

- **Blood spatter 1 is travelling faster than blood spatter 2**
- **Blood spatter 2 is travelling slower than blood spatter 1**
- **Blood spatter 1 and 2 are travelling from different source directions**

30. (5 points) Using Figures 8, 9, 10, 11, and 12, write down each Pokémon's DNA sequence. Assume the right and left sides of the diagram correspond to 5' and 3', respectively.

Solution:

- **Bulbasaur: 5' ATC GAA GTC GCA TTC 3'**
- **Charmander: 5' AGC AAG TTG CAC CGA 3'**
- **Squirtle: 5' TGG TAC TAC TAG TGC 3'**
- **Eevee: 5' ATC ACA GGT AGA TCC 3'**
- **Ditto: 5' AGT TAA CGA TCG TAA 3'**

31. (1 point) Detective Pikachu was able to get a DNA sample from the stolen Golden Berry. Write out the DNA sequence shown on this PAGE Gel. Label 5' and 3' ends.

Solution: 5' ATC GAA GTC GCA TTC 3'

Analysis (TB1)

32. (52 points) Who committed the crime? Include all relevant information. Cite motives and alibis for each suspect.

Solution:

- **Bulbasaur and Squirtle worked together to commit the crime. (5)**
- **Motive: Feeling they were treated unfairly, Bulbasaur had planned to steal the golden berry for themselves. But when Squirtle caught Bulbasaur, Bulbasaur tried to convince Squirtle to keep quiet and in return would give some to Squirtle. (5)**
- **2 points for every bullet point addressed. (Mention 2 powders enough to receive all 2 points for bullet point.)**

Bulbasaur

- **Powders: 1, 2, 4, 5, 6, 9 (Table Salt + Cornstarch mixture, Crystal Sugar + Flour mixture, Powdered Gelatin, Baking Soda, Table Salt, Cornstarch)**
- **Metals: 1 (Tin)**
- **Liquids: 2 (Water)**
- **Fibers: 1, 2 (Vegetable, Animal)**
- **Hair: 2 (Rat Hair)**
- **DNA: Sample matches PAGE Gel**

Squirtle

- **Powders: 8 (Calcium Carbonate)**
- **Metals: None**
- **Liquids: None**
- **Fibers: 2 (Animal)**
- **Hair: 2 (Rat Hair)**

Charmander

- **Powders: 3, 7, 9 (Anhydrous Sodium Acetate, White Sand, Powdered Alka-Seltzer)**
- **Metals: None**
- **Liquids: None**
- **Fibers: 2 (Animal)**
- **Hair: 2 (Rat Hair)**

Eevee

- **Powders: None**
- **Metals: None**
- **Liquids: None**
- **Fibers: 2 (Animal)**
- **Hair: 2 (Rat Hair)**

Ditto

- **Powders: None**
- **Metals: None**
- **Liquids: 1, 3 (Rubbing Alcohol, Vinegar)**
- **Fibers: 2 (Animal)**
- **Hair: 2 (Rat Hair)**